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IN OPEN AND ENCLOSED HOUSING

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ABSTRACT

Performance of two strains of laying hens in enclosed housing with mechanically controlled ventilation set to provide either high (8-12 cfm per bird) or low (3.5-6 cfm per bird) ventilation rates or naturally ventilated open-sided housing was compared. A total of 1728 pullets (Hy-line W36 and Shaver Starcross 288) housed at the rate of 3 birds per 12-x-18-inch cage were started on experiment at 22 weeks of age and continued on trial for a period of 56 weeks. Mean hen-day egg production for Shaver hens was 72.5 percent in enclosed houses with high ventilation rates, 72.1 percent in enclosed houses with low ventilation rates, and 72.4 percent in open houses; production for Hy-line hens was 67.8, 65.5, and 70.3 percent, respectively. Differences due to housing were not significant; however, strain differences were statistically significant. Feed efficiency was significantly affected by type of housing and strain of layer. Pounds of feed required to produce a dozen eggs averaged 3.47, 3.45 and 3.54 for Hy-line layers in the enclosed houses and open house, respectively, and 3.64, 3.61 and 3.78, respectively, for Shaver layers. Both strains in the enclosed houses were more efficient than in the open house. Shaver hens laid significantly larger eggs than did Hy-line hens; however, Hy-line hens produced eggs with significantly thicker shells and significantly fewer cracks. Strain differences in albumen quality were significant since Shaver hens produced eggs with higher albumen quality. There were no strain differences in mortality; however, mortality was significantly higher among both strains of hens in the open house as compared to hens in the enclosed houses. Income per hen housed over pullet, feed and electricity costs from maintaining hens in the enclosed houses with high and low ventilation rates was \$3.19 and \$3.18 per bird, respectively, and \$2.98 per bird maintained in the open house.

INTRODUCTION

Previous work in Hawaii (Herrick and Ross, 1974) has shown that enclosed housing with controlled ventilation improved layer efficiency over that of layers in naturally ventilated open housing, although environmental conditions for birds in the enclosed housing were not considered optimum. The present study was an attempt to provide laying hens with a more comfortable environment, thereby further increasing bird efficiency by the utilization of enclosed housing. In addition, performance characteristics of two strains of layers were investigated to determine whether strain differences exist under different housing conditions in Hawaii.

MATERIALS AND METHODS

Pullet chicks (Hy-line W36 and Shaver Starcross 288) were reared under similar conditions of management. At 18 weeks of age they were transferred to 12-x-18-inch laying cages in three experimental houses. An enclosed house, 24 x 96 feet, was partitioned into two separate units, each 24 x 48 feet. The third house was an open-sided conventional poultry house. Both enclosed houses had 1 1/2-inch air intake slots located at the eaves below the ceiling level. One fan (3/4-HP 24-inch, 2-speed) was located at a corner of each house exhausting downwind. The air intake slot, designed to provide a high degree of light blockage, extended

continuously along the length of each house and on the opposite side except for an area 8 feet from the fan. Ventilation systems were similar in both enclosed houses, except the exhaust fans in each house were set at different speeds to provide different ventilation rates. In one enclosed house, hereafter designated high ventilation rate house, the fan was adjusted to provide 12 cfm per bird at high speed and 8 cfm per bird at low speed. In the other enclosed house, hereafter designated low ventilation rate house, the fan was set to provide an air velocity of 6 cfm per bird at high speed and 3.5 cfm per bird at low speed. A differential thermostat for the fan in each house was set so fans would be on high speed when cage area temperatures exceeded 83°F.

Each experimental house contained six rows of 32 cages. Each row was divided into 4 replicates of 8 cages, making a total of 24 replicates containing 192 cages in each house. A randomized block design was utilized so that each of the two strains of layers was represented by 2 replicates of 8 cages each per row, making a total of 12 replicates of each strain per house. Three birds were assigned per cage. Therefore, there were 12 replicates of 24 birds each, or a total of 288 birds of each strain in each experimental house.

The birds were kept in the laying cages during the 56-week experimental period which commenced when the birds were 22 weeks of age (April 3, 1974).

During the experiment, all birds were given feed and water ad libitum. Birds in all houses were provided with 14 hours of light per day from 20 to 66 weeks of age, when the light exposure was increased, to 15 hours per day for the remainder of the laying period (78 weeks of age). The light intensity in the enclosed houses was reduced with dimmer switches to less than 1 foot-candle to conserve fuel and reduce activity among the hens except for short periods during the day when feed was added, eggs were collected or manure was removed, at which time an override switch allowed for full illumination. Birds in the open house received a combination of natural light supplemented with artificial light, which averaged over 3 foot-candles. Each experimental house was equipped with a separate meter to record power consumption for lights; in addition, the two enclosed houses had separate meters to record power consumption by the fans.

During the course of the experiment, continuous temperature and relative humidity values were recorded by hygrothermographs located within each house.

Ammonia concentrations within each house were tested frequently throughout the course of the experiment by utilizing a slightly modified method of Moum, et al., 1969.¹

Data on sexual maturity, egg production, egg weight, egg quality, shell thickness, cracked eggs, feed efficiency and mortality were recorded. Birds were weighed by replicate at the beginning and end of the experiment. Where appropriate, means of each parameter of all replicates of each strain of each treatment were calculated and analyzed by analysis of variance.

RESULTS AND DISCUSSION

Egg Production

As shown in Table 1, percent hen-day egg production was not significantly affected by differences in housing; however, strain differences were significant. The mean hen-day egg production was 72.5 and 72.1 percent for Shaver hens in the enclosed houses with high (8-12 cfm/bird) and low (3.5-6 cfm/bird) ventilation rates, respectively, and 72.4 percent for Shaver hens in the naturally ventilated open house. Mean hen-day production values for Hy-line hens in the high and low ventilation rate enclosed houses and open house were 67.8, 65.5 and 70.3 percent, respectively. Previous work (Herrick and Ross, 1974; 1975) also has shown no significant differences in hen-day egg production between birds housed in enclosed and open houses. The strain differences in mean hen-day egg production may have been influenced in part by the significantly slower development of sexual maturity among the Hy-line pullets. Days to first egg were 153, 152 and 154 among Hy-line pullets in the high and low ventilation rate

enclosed houses and open house, respectively, while days to first egg were 144, 144 and 148, respectively, among Shaver pullets (Table 1). The strain difference in sexual maturity was also reflected in a significant difference in days to 50 percent production between the two strains. Days to 50 percent production were 174, 173 and 174 among Hy-line pullets in the high and low ventilation rate enclosed houses and open house, respectively, while Shaver pullets required 165, 166 and 167 days, respectively, to reach 50 percent production (Table 1).

No significant differences in hen-housed egg production were observed due either to type of housing or strain of layer (Table 1). The mean hen-housed egg production was 65.2, 61.9 and 64.6 percent among Hy-line hens in the high and low ventilation rate enclosed houses and open house, respectively, and 68.2, 68.4 and 62.1 percent, respectively, among Shaver hens. The lack of significant strain differences in hen-housed egg production may be due in part to the higher mortality among Shaver birds, particularly among those in the open house. Mortality was 20.1, 19.6 and 26.8 percent among Shaver hens in the high and low ventilation rate houses and open house, respectively, and 16.6, 19.7 and 21.6 percent, respectively, among Hy-line hens (Table 1). Mortality was significantly higher among both strains of hens in the open house than among birds in the enclosed houses. Higher mortality among birds in an open laying house than among birds in enclosed housing was also reported in a previous trial (Herrick and Ross, 1974).

Feed Efficiency and Gain in Body Weight

Feed efficiency was significantly affected by type of housing and strain of layer. As shown in Table 1, feed required to produce 1 dozen eggs was 3.47, 3.45 and 3.54 pounds for Hy-line hens in the high and low ventilation rate enclosed houses and open house, respectively, and 3.64, 3.61 and 3.78 pounds, respectively, for Shaver hens. Both strains of layers in the enclosed houses were more efficient converters of feed to eggs than were the same strains in the open house. These results agree with those of previous trials at this station (Herrick and Ross, 1974; 1975). It is apparent from the data in Table 1 that the Hy-line layers were significantly more efficient feed converters than the Shaver hens. The body weight of the Shaver hens averaged nearly 0.14 pound more than that of the Hy-line hens at the termination of the trial, and this would account in part for differences in feed efficiency as the Shaver hens would require more feed for body maintenance.

Average gains in body weight were 1.20, 1.16, and 0.95 pounds among Hy-line hens in the high and low ventilation rate houses and open house, respectively, and 1.11, 1.15 and 0.94 pounds, respectively, for the Shaver hens (Table 1). Both strains of layers maintained in the enclosed houses gained significantly more weight than the same strains maintained in the open house. This weight increase may be related in part to the low light intensity in the enclosed houses, which caused hens to be less active than hens in the brighter, open house. This low light factor may also have influenced feed efficiency among hens in the enclosed houses, as they would require less energy for activity than would the more active hens in the open house. There were no

¹/Test kit available from Vineland Laboratories, Inc., Vineland, N.J.

significant strain differences in body weight gains.

Egg Weight and Egg Quality

Average individual egg weights were 2.17, 2.13 and 2.22 ounces for eggs laid by Hy-line hens maintained in the enclosed houses with high and low ventilation rate and the open house, respectively, while weights for eggs laid by Shaver hens in the three houses were 2.19, 2.19 and 2.21 ounces, respectively (Table 1). Egg weight differences between strains and locations were significant. Shaver hens laid significantly larger eggs than did Hy-line hens, with Shaver hens in all locations averaging eggs weighing 2.20 ounces as compared to 2.17 ounces for eggs laid by Hy-line hens. This larger size of eggs laid by Shaver hens is certainly due in part to the heavier average body weight of the Shaver hens as discussed previously. Significantly larger eggs were produced by both strains of layers in the open housing than by similar hens in either enclosed house. The reason for this difference in egg size due to location is not clear, although the trend among commercial layers in open houses to produce slightly larger eggs than similar layers in enclosed housing has been previously reported (Herrick and Ross, 1974; 1975).

Albumen quality was measured in Haugh Units. The mean Haugh Units for eggs laid by Hy-line hens in the enclosed houses with high and low ventilation rates and the open house were 66.2, 67.1, and 69.7, respectively, while the mean Haugh Unit values for eggs laid by Shaver hens in the three houses were 71.5, 73.6 and 72.3, respectively (Table 1). There were no significant effects upon albumen quality due to type of housing; however, strain differences in albumen quality were significant. The Shaver hens produced eggs with higher albumen quality.

Shell thickness was affected significantly by both type of housing and strain of layer. Shell thickness of eggs laid by Hy-line hens in the high and low ventilation rate houses and open house averaged 14.9, 14.6 and 15.1 thousandths of an inch, respectively, while shell thickness of eggs laid by Shaver hens in the three types of housing averaged 14.1, 14.2 and 14.6, respectively (Table 1). Both strains of layers in the open house produced eggs with thicker shells than did the same strains of layers in the enclosed housing. The reason for this difference in shell quality between layers in the two types of housing is not clear. Herrick and Ross (1974) noted that layers in open, naturally ventilated housing produced thicker shelled eggs than did layers in enclosed, controlled ventilation housing, although differences in shell thickness were not significant. Hy-line strain layers in the present study produced eggs with significantly thicker shells than did the Shaver strain layers, regardless of the type of housing. This strain difference in shell quality is also reflected in the significantly greater numbers of cracked eggs recorded among the eggs produced by the Shaver hens. The percentage of cracked eggs recorded among eggs laid by Shaver hens in the enclosed high and low ventilation rate houses and open house averaged 5.6, 5.6 and 5.4 compared with 4.5, 4.5 and 3.7 by Hy-line hens (Table 1). The significantly higher incidence of cracked eggs produced

by Shaver hens may be related to the thinner shells of these eggs as a significant inverse relationship between shell thickness and percentage of cracked eggs has been demonstrated (Tyler and Geake, 1960; Bowman and Challender, 1962).

Environmental Data

Mean poultry house temperature and relative humidity values, calculated from continuous recordings, are presented in Table 2. Daily high temperatures averaged 83.7, 83.6 and 80.3°F in the enclosed houses with high and low ventilation rate and the open house, respectively, and daily low temperatures in the three houses averaged 71.4, 73.8 and 70.1°F, respectively. Hens in the enclosed houses with controlled ventilation were exposed to slightly higher environmental temperatures than were those in the open, naturally ventilated house. Although temperatures fluctuated, as indicated by the ranges in Table 2, the average daily high and low temperatures in all houses fell within a range considered satisfactory for maintaining adequate egg production (Payne, 1966). In the present trial no significant effects of environmental temperature upon production were observed between strains of layers tested.

It is known that high humidity may affect laying hen performance, particularly if temperatures are high. Lampman et al. (1967) indicated a relative humidity of 60 percent is desirable if poultry house temperatures are in the 65-85°F range, and Longhouse et al. (1960) recommended that maximum poultry house relative humidity not exceed 80 percent. The average high daily relative humidity in the present study averaged 90.4, 88.7 and 93.5 percent in the enclosed houses with high and low ventilation rates and the open house, respectively. Although these relative humidity values are high, no adverse effects upon egg production, egg size or shell thickness were observed among hens of either strain which could be attributed to temperature or humidity.

Mean ammonia concentrations within each poultry house were calculated from measurements taken throughout the course of the experiment. The ammonia concentration averaged 6.0, 9.0 and 2.0 ppm in the enclosed houses with high and low ventilation rates and the open house, respectively. Neither strain of layer appeared to be affected by ammonia in the atmosphere. Although ammonia levels were higher in the enclosed houses than in the open house, these levels were below the 20 ppm or more shown to affect chickens (Longhouse, et al., 1963; Anderson, et al., 1964).

Total electricity consumption for light was 1928 KWH in each of the enclosed houses and 784 KWH in the open house (Table 2). The higher power consumption for light in the enclosed houses is due to the need for greater light intensity during periods of egg collection and hand feeding in addition to the full 14 or 15 hours per day of exposure to dimmed light, while the open house needed only approximately 1 to 3 hours per day of artificial light supplementation. The fan in the enclosed house with the higher rate of ventilation utilized 1276 KWH of electricity, whereas the one in the low ventilation rate house utilized only 595 KWH, less than one-half this amount.

APPLICATION OF RESULTS

Income from the sale of marketable eggs and spent hens and the cost of pullets, feed and electricity for maintaining two strains of hens in enclosed houses with high and low ventilation rates and an open house are shown in Table 3. The average egg sale price used for calculation was 57.6 cents per dozen, the average farm price during the experimental period obtained from Hawaii Crop and Livestock Reporting Service data. The value of spent hens was obtained by multiplying the final body weight by 8 cents per pound, a figure based on the average farm price for spent hens (Hawaii Crop and Livestock Reporting Service preliminary estimate, April 1975). The cost of pullets at 18 weeks was estimated at \$2.25 each for both strains of layers. Feed costs were estimated at \$180.00 per ton. Electricity costs were calculated from Hawaiian Electric Company's general lighting and commercial air conditioning rate schedules for use of lights and ventilation fans, respectively.

The effect of housing can be seen by noting the income derived over pullet, feed and electricity cost from maintaining both strains of birds in the different houses. Income per bird housed from layers in the enclosed houses with high and low ventilation rates was \$3.19 and \$3.18 per bird, respectively, and \$2.98 per bird in the open house. It is obvious from these results that layers can be maintained as profitably in enclosed housing as layers in conventional open housing when considering pullet, feed and electricity costs. It should be noted, however, that both strains of layers suffered significantly greater mortality losses in the open house than in the enclosed housing, and this naturally adversely affected total income per bird housed. In addition, feed efficiency among both strains of layers was significantly better among hens in enclosed housing than among those in the open housing. This also contributed to increased income from hens in enclosed housing and more than compensated for increased consumption of electricity in the mechanically ventilated houses. Herrick and Ross (1975) reported similar results among hens housed in Hawaii, and Baker (1969) in California and Harwood (1972) in North Carolina showed a greater return per hen in enclosed housing over hens in open housing.

Strain differences among layers were also observed in response to differences in housing. Based upon the income per strain housed (Table 3), Hy-line layers produced most profitably in the open house and least profitably in the low ventilation rate house. Shaver hens, on the other hand, performed most profitably in the low ventilation rate house and least profitably in the open house where the birds were exposed to higher, uncontrolled ventilation rates. Income from Hy-line strain birds in the three

experimental houses averaged \$3.19 per bird; income per Shaver hen averaged \$3.05. Although it is obvious from the results of this trial that strain differences exist in the response of layers to differences in housing conditions, it is presumptuous to draw conclusions regarding selection of a strain of layer for commercial egg production from the results of only one trial. Tests to further investigate the performance of various layer strains maintained under different housing conditions are currently under consideration at this station.

REFERENCES

- Anderson, D.P., C.W. Beard, and R.P. Hamon. 1964. The adverse effects of ammonia on chickens, including resistance to infection with Newcastle disease virus. *Avian Disease* 8:369-379.
- Baker, A. 1969. Trend: Closed layer housing in California. *Poultry Digest* 28:554.
- Bowman, J.C., and N.I. Challender. 1962. Egg shell strength. A comparison of two laboratory tests and field tests. *British Poultry Sci.* 4:103-116.
- Harwood, D.G. 1972. Economics of environmental control in broiler, egg production housing. *Feedstuffs* 44:40.
- Herrick, R.B., and E. Ross. 1974. Effect of enclosed housing and bird concentration upon the performance of caged layers in Hawaii. *Hawaii Agr. Exp. Sta. Res. Rep.* 201.
- Herrick, R.B., and E. Ross. 1975. Enclosed layer housing in Hawaii. *Hawaii Agr. Exp. Sta. Dep. Paper* 36.
- Lampman, C.E., J.E. Dixon, C.F. Petersen, and R.E. Black. 1967. Environmental control for poultry housing. *Idaho Agr. Exp. Sta. Bull.* 456.
- Longhouse, A.D., G.O. Bressler, C.S. Shaffner, and H.L. Garver. 1963. Poultry housing--Basic data useful for design purposes in the Northeastern states. *West Virginia Agr. Exp. Sta. Bull.* 486-T.
- Moum, S.G., W. Seltzer, and T.M. Goldhaft. 1969. A simple method of determining concentrations of ammonia in animal quarters. *Poultry Sci.* 48:347-348.
- Payne, C.G. 1966. Environmental temperature and egg production. In C. Horton-Smith and E.C. Amoroso, eds. *Physiology of the Domestic Fowl*. Oliver and Boyd, Edinburgh.
- Tyler, C., and F.H. Geake. 1960. Studies on egg shells. XIII. Influence of individuality, breed, season and age on certain characteristics of egg shells. *J. Sci. Food Agr.* 11:535-547.

Table 1. Mean performance data of two strains of layers caged in enclosed houses with controlled ventilation rates and an open house with natural ventilation

Characteristic	Enclosed houses				Open house, natural ventilation	
	High controlled ventilation		Low controlled ventilation			
	Hy-line	Shaver	Hy-line	Shaver	Hy-line	Shaver
Egg production (%) ^{1/}						
Hen-day	67.8 ^{a2/}	72.5 ^b	65.5 ^a	72.1 ^b	70.3 ^a	72.4 ^b
Hen-housed	65.2 ^a	68.2 ^a	61.9 ^a	68.4 ^a	64.6 ^a	62.1 ^a
Feed required to produce 1 doz eggs (lb) ^{1/}	3.47 ^a	3.64 ^c	3.45 ^a	3.61 ^c	3.54 ^b	3.78 ^d
Gain in body weight (lb) ^{1/}	1.20	1.11	1.16	1.15	0.95 ^a	0.94 ^a
Egg weight (oz)	2.17 ^a	2.19 ^b	2.13 ^a	2.19 ^b	2.22 ^c	2.21 ^c
Albumen quality (Haugh Units)	66.2 ^a	71.5 ^b	67.1 ^a	73.6 ^b	69.7 ^a	72.3 ^b
Shell thickness (1 unit = 0.001 in.)	14.9 ^b	14.1 ^a	14.6 ^b	14.2 ^a	15.1 ^c	14.6 ^b
Cracked eggs (%)	4.47 ^a	5.55 ^b	4.53 ^a	5.59 ^b	3.71 ^a	5.38 ^b
Mortality (%) ^{1/}	16.6 ^a	20.1 ^a	19.7 ^a	19.6 ^a	21.6 ^b	26.8 ^b
Days to 1st egg	153 ^b	144 ^a	152 ^b	143 ^a	154 ^b	147 ^a
Days to 50% egg production	174 ^b	165 ^a	173 ^b	166 ^a	174 ^b	167 ^a

^{1/}Results based on 56-week production period.

^{2/}Values in the same horizontal line followed by the same superscript are not significantly different (P<0.01).

Table 2. Environmental data from enclosed houses with controlled ventilation rates and open house with natural ventilation

Item	Enclosed houses				Open house, natural ventilation	
	High ventilation		Low ventilation			
	Average	Range	Average	Range	Average	Range
Temperature (°F)						
Average daily high	83.7	75-92	83.6	72-92	80.3	68-88
Average daily low	71.4	55-73	73.8	62-81	70.1	56-77
Humidity (%)						
Average daily high	90.4	72-100	88.7	68-100	93.5	70-100
Average daily low	61.9	46-74	63.9	45-78	62.9	48-78
Ammonia concentration (ppm)	6.0	5-10	9.0	5-20	2.0	0-5
Electricity consumption (KWH)						
Fan	1276		595		--	
Light	1928		1928		784	

Table 3. Income over pullet, feed and electricity cost of two strains of caged layers in enclosed houses with controlled ventilation rates and an open house with natural ventilation

Item	Enclosed houses				Open house, natural ventilation	
	High controlled ventilation		Low controlled ventilation			
	Hy-line	Shaver	Hy-line	Shaver	Hy-line	Shaver
Income						
Egg sales (57.6¢/doz) ^{1/}	\$3,532.03	\$3,701.38	\$3,352.90	\$3,704.83	\$3,503.81	\$3,367.30
Salvaged hens (8¢/lb) ^{2/}	73.92	71.94	70.04	73.87	64.54	62.96
Total	\$3,605.95	\$3,773.32	\$3,422.94	\$3,778.70	\$3,568.35	\$3,430.26
Expenses						
Initial hen value (\$2.25/hen)	\$ 648.00	\$ 648.00	\$ 648.00	\$ 648.00	\$ 648.00	\$ 648.00
Feed cost (\$180.00/ton)	1,924.20	2,098.80	1,800.00	2,084.40	1,935.00	1,983.60
Electricity ^{3/}	112.46	112.46	93.88	93.88	32.58	32.58
Total	\$2,684.66	\$2,859.26	\$2,541.88	\$2,826.28	\$2,615.58	\$2,664.18
Income over pullet, feed and electricity cost	\$ 921.29	\$ 914.06	\$ 881.06	\$ 952.42	\$ 952.77	\$ 766.08
Income per bird housed over pullet, feed and electricity cost	\$ 3.20	\$ 3.17	\$ 3.06	\$ 3.31	\$ 3.31	\$ 2.66
Average per bird income by house	\$3.19		\$3.18		\$2.98	

^{1/}Average farm price (1974 + preliminary estimates 1st quarter 1975), Hawaii Cooperative Crop and Livestock Reporting Service.

^{2/}Average farm price (preliminary estimates April 1975), Hawaii Cooperative Crop and Livestock Reporting Service.

^{3/}Rates established by Hawaiian Electric Company based on commercial levels of consumption (1974, 1st quarter 1975).



